Preliminary observations on the effects of rotation of crops and fertilizers on Collembola

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Introduction

Since past two decades considerable attention is being directed to the effects of agricultural practice on soil-fauna, specially soil microarthropods, which are considered so useful for mineralisation process in the soil. Notable amongst the works published on arable soils, particularly in relation to springtails and other microarthropods, are those by EDWARDS *et al.* (1963, 1964, 1965, 1967, 1969), WAY *et al.* (1968), POPOVICI *et al.* (1977), WIBO (1973), GRIFFITHS *et al.* (1967), RAFFENSPERGER (1969), DRAKE *et al.* (1971), HEIJBROEK (1973). Most of these works, however, pertain to the arable soils in temperate countries and were summarised by WALLWORK (1976). BHATTACHARYA *et al.* (1977, 1980) studied the effects of two herbicides in relation to wheat and paddy cultivations in laterite soil of West Bengal. In the present paper, preliminary observations on cumulative effects of various agricultural practices are presented on the basis of observations made since 1978.

Experimental sites and methods

Soil samples were drawn monthly from adequately replicated experimental plots at the Jute Agricultural Research Institute (JARI), Barrackpore, West Bengal (India) where long term fertilizer experiments are being conducted since 1971 with rotation of three crops, viz., wheat, jute and paddy with the application of various doses of N.P.K. and F.Y.M., adoption of plant protection measures, periodic irrigation, etc. (Tables I and II).

TABLE I

Actual details of the treatments. (* This plot was not sampled).

Treatments	Jute Var-JRO 7835	Paddy Var-Jaya	Wheat Var-Sonalika
T_1	$N_{30}P_{15}K_{30}$ + Hand weeding	$N_{60}P_{30}K_{30}$	$N_{60}P_{30}K_{30}$
T_2	$N_{60}P_{30}K_{60}$ + Hand weeding	$N_{120}P_{60}K_{60}$	$N_{120}P_{60}K_{60}$
T_3	$N_{90}P_{45}K_{90}$ + Hand weeding	$N_{180}P_{90}K_{90}$	$N_{180}P_{90}K_{90}$
T_4	$N_{60}P_{30}K_{60}$ + Hand weeding	$N_{120}P_{60}K_{60}$ + Hand weeding	$N_{120}P_{60}K_{60}$ + Hand weeding
*T_5	$N_{60}P_{30}K_{60}$ + Hand weeding	$N_{120}P_{60}K_{60}$	$N_{120}P_{60}K_{60}$ + $ZnSO_4$ @ 10 kg/ha
T_6	$N_{60}P_{30}K_0$ + Hand weeding	$N_{120}P_{60}K_0$	$N_{120}P_{60}K_0$
T_7	$N_{60}P_0K_0$ + Hand weeding	$N_{120}P_0K_0$	$N_{120}P_0K_0$
T_8	$N_{60}P_{30}K_{60}$ + Hand weeding + FYM @ 10 t/ha	$N_{120}P_{60}K_{60}$	$N_{120}P_{60}K_{60}$
T_9	$N_{60}P_{30}K_{60}$ + Chemical weeding	$N_{120}P_{60}K_{60}$ + Chemical weeding	$N_{120}P_{60}K_{60}$ + Chemical weeding
T_{10}	Control + Hand weeding	Control	Control
Fallow	—	—	—

Simultaneously, samples were also drawn from another site, viz., Bankrahat, 24-Parganas, near Calcutta Air-Port, where mixed cultivation is practiced with jute as one of the crops without application of chemical fertilizers, pesticides, weedicides, etc. Soil type at both the sites comes under the broad group new alluvium. Each sampler, used for sampling in this investigation, is 9 cm long with a cross sectional area of 28.29 cm^2 having a sharp cutting edge. Soil samples were extracted through a modified Tullgren apparatus, specially designed for this purpose by the first author.

TABLE II

Lay-out of the experiment.

Treatments	10
Replications	4
Design	R.B.D.
Plot size	20m x 10m
Fertilizer Sources	Urea, D.A.P., Superphosphate, Ammonium Sulphate, Potassium chloride
Rotation	A three-crop rotation consisting of two cereals (Paddy and Wheat) and one fibre crop (Jute).

Results and discussion

It would be evident from table III that fourteen species occur at experimental plots in JARI in contrast to sixteen species at Bankrahat. *Subisotoma fitchioides, Stenacidia* sp., *Brachystomella* sp., *Deuterosminthurus* sp. and *Bourletiella* sp. are specific for JARI. This presumably indicates that application of pesticides, chemical fertilizers, weedicides, etc. have little effect on these species. In contrast to the five species specific for JARI, there are eight species specific for Bankrahat; such higher species-specificity at this site might be due to mixed cultivation or susceptibility of these species to the agricultural practices at JARI.

Crop-wise analysis of the species occurring at JARI shows that *Cryptopygus thermophilus* remains associated with the rotation of all the three crops (Table IV). *Subisotoma fitchioides* and *Deuterosminthurus* sp. occurred only during cultivation of jute. *Isotomurus balteatus*, most predominant quantitatively, appeared during cultivation of paddy and reached its climax during wheat cultivation. *Xenylla welchi, Folsomides parvulus, Sphaeridia cornuta* and *Stenacidia* sp. occurred only during paddy cultivation.

Cultivation of wheat not only gave rise to abundance in population, a good number of genera/species like *Brachystomella* sp., *Bourletiella* sp., *Entomobrya* sp., and *Lepidocyrtus* sp. also came into being during this period. This enrichment is probably due to availability of more organic matter (resulting from the decaying stubs and roots of jute and paddy) as well as the absence of pesticides during wheat cultivation.

A month wise comparison of total collembolan fauna including genera/species, obtained from JARI with Bankrahat shows that jute cultivation at Bankrahat encouraged better development of Collembola qualitatively : thus in contrast to five species at JARI, jute cultivation at Bankrahat supported eight genera/species of Collembola. Leaving three species *(Cryptopygus thermophilus, Cyphoderus javanus* and *Sminthurides appendiculatus*) common to both sites, the species like *Seira lateralis, Isotomiella minor, Folsomides parvulus, Lepidocyrtus* sp., *Heteromuricus cercifer* were found to remain associated with the jute cultivation at Bankrahat. It is of interest to mention that the species of *Lepidocyrtus* which remained unrepresented in the samples drawn during jute and paddy cultivation at JARI, appeared during wheat cultivation and *Folsomides parvulus* only during paddy cultivation. Appearance of *Lepidocyrtus* sp. only during wheat cultivation at JARI presumably indicates the susceptibility of the species to pesticides, if not to chemical fertilizers.

TABLE III

Qualitative analysis of Collembola from JARI, Barrackpore and Bankrahat, 24-Parganas.

JARI, Barrackpore	**Bankrahat, 24-Parganas**
1) *Sminthurides appendiculatus* Imms	1) *Sminthurides appendiculatus* Imms
2) *Cryptopygus thermophilus* (Axelson)	2) *Cryptopygus thermophilus* (Axelson)
3) *Cyphoderus javanus* Borner	3) *Cyphoderus javanus* Borner
4) *Isotomurus balteatus* (Reuter)	4) *Isotomurus balteatus* (Reuter)
5) *Subisotoma fitchioides* (Denis)	5) *Seira lateralis* Yosii
6) *Stenacidia* sp.	6) *Isotomiella minor* (Schaeffer)
7) *Brachystomella* sp.	7) *Folsomides*
8) *Bourletiella* sp.	8) *Lepidocyrtus* sp.
9) *Entomobrya* sp.	9) *Heteromuricus cercifer* Imms
10) *Sphaeridia cornuta* Murphy	10) *Acherontiella* sp.
11) *Lepidocyrtus (Ascocyrtus)* sp.	11) *Isotoma* sp.
12) *Folsomides parvulus* Stach	12) *Sinella (Coecobrya)* sp.
13) *Xenylla welchi* Folsom	13) *Entomobrya* sp.
14) *Deuterosminthurus* sp.	14) *Sminthurinus* sp.
	15) *Sphaeridia* sp.
	16) *Proisotoma* sp.

Genera/species specific at JARI, Barrackpore and Bankrahat, 24-Parganas

JARI, Barrackpore	**Bankrahat, 24-Parganas**
1) *Subisotoma fitchioides* (Denis)	1) *Seira lateralis* Yosii
2) *Stenacidia* sp.	2) *Isotomiella minor* (Schaeffer)
3) *Bourletiella* sp.	3) *Heteromuricus cercifer* Imms
4) *Brachystomella* sp.	4) *Acherontiella minor* (Schaeffer)
5) *Deuterosminthurus* sp.	5) *Isotoma* sp.
	6) *Sinella (Coecobrya)* sp.
	7) *Sminthurinus* sp.
	8) *Proisotoma* sp.

Genera/species common to both JARI, Barrackpore and Bankrahat, 24-Parganas

1) *Sminthurides appendiculatus* Imms
2) *Cryptopygus thermophilus* (Axelson)
3) *Cyphoderus javanus* Borner
4) *Isotomurus balteatus* (Reuter)
5) *Entomobrya* sp.
6) *Sphaeridia* sp.
7) *Lepidocyrtus* sp.
8) *Folsomides parvulus* Stach

TABLE IV

Occurrence of collembolan species with rotation of three crop-types at JARI, Barrackpore.

Species	Vegetation		
	Jute	Wheat	Paddy
Isotomurus balteatus (Reuter)	−	+	+
Brachystomella sp.	−	+	−
Bourletiella sp.	−	+	−
Cryptopygus thermophilus (Axelson)	+	+	+
Entomobrya sp.	−	+	+
Subisotoma fitchioides (Denis)	+	−	−
Sminthurides appendiculatus Imms	+	−	+
Deuterosminthurus sp.	+	−	−
Cyphoderus javanus Borner	+	−	+
Xenylla welchi Folsom	−	−	+
**Folsomides parvulus* Stach	−	−	+
Sphaeridia cornuta Murphy	−	−	+
Stonacidia sp.	−	−	+
Lepidocyrtus sp.	−	+	−

* Also occurs during jute cultivation at Bankrahat.

Collembolans exhibit greater susceptibility to Thiodan EC 35. Its residual effect persisted till the time of cultivation of paddy, *i.e.*, for more than three months which is indicated by their total absence in the samples for three months after its application. Samples extracted within two weeks after the application of Furadan 3 G showed the appearance of five species of Collembola, viz., *Isotomurus balteatus, Subisotoma fitchioides, Cryptopygus thermophilus, Stenacidia* sp. and *Sminthurides* sp. Less susceptibility of Collembola towards Furadan 3G (a carbamate compound) than Thiodan EC 35 (Chlorinated hydrocarbon compound) is, therefore, indicated owing to their differential residual effects. Throughout the period of wheat cultivation no pesticides were applied. During this period collembolans exhibited a sharp rise in population both quantitatively and qualitatively.

From Fig. 1, cumulative effects of agricultural practices on population dynamics of Collembola will be evident.

Analysis of six months' data obtained during wheat cultivation shows that the highest population build-up of Collembola was associated with T_4 (32.07 %), followed by T_8 (22.64 %), T_9 (16.98 %), T_1 and T_6 (9.43 %), T_2 and T_3 (3.77 %) and T_7 (1.88 %) respectively. T_4 and T_8 receive the identical dose of fertilizers. T_4 underwent periodic hand-weeding in contrast to T_8 where there was no weeding and which received a regular dose of F.Y.M. (10 t/ha) during jute cultivation. In T_4 collembolans appeared in samples during two months while in T_8, they appeared during four months, out of six months. T_8 and T_9 though received the same dose of N.P.K., lower population build-up in the later might be due to chemical weeding; while difference in population of Collembola between T_2 and T_8, receiving the identical dose of N.P.K., may be for addition of F.Y.M. in T_8 during jute cultivation. T_1 and T_8 supported the same population, though T_1 received half dose of N and P of that of T_6 and K_{30}, which was not applied to T_6 during wheat cultivation.

An analysis of eight months' data obtained during jute cultivation shows that highest population build-up of Collembola was associated with T_4 (27.27 %) followed by T_1 (18,18 %), T_7 (15.15 %), T_8 (13.63 %),

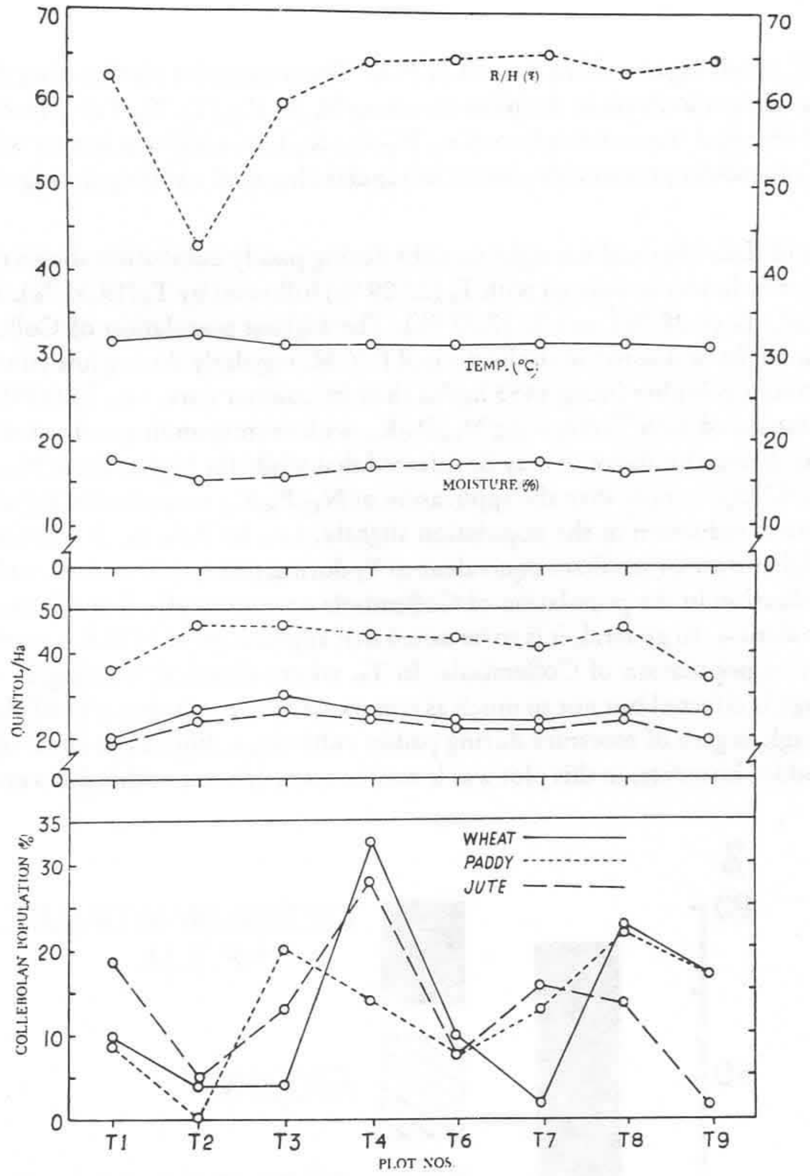

Figure 1 Cumulative effect of fertilizer experiment on collembolan population and yield.

T_3 (12.12 %), T_6 (7.57 %), T_2 (4.45 %) and T_9 (1.51 %). It would be evident from above that T_2, T_4 and T_9 though received the same dose of N.P.K. during all the three rotations of crops, there remains a good deal of difference from the point of view of collembolan population. It may be noted that T_2 had no weeding during wheat and paddy cultivations, in contrast to T_4, where there was regular hand weeding during cultivation of all the three crops and in T_9 there was regular chemical weeding. Thus it appears while periodic hand weeding encourages the greater development of euedaphic Collembola (as in T_4 vs. T_2), chemical weeding depresses its development (as in T_9). However, an overall analysis of data shows that T_2, T_4, T_8 and T_9 (receiving $N_{60}P_{60}K_{60}$), irrespective of the criterion of weeding, supported highest population of Collembola (46.87 %) followed by T_1 (18.18 %) receiving half dose of N.P.K. ($N_{30}P_{15}K_{30}$). Increase in the dose of N without addition of P and K lowered the population (15.15 %) as in T_7 receiving N_{60} P_0 K_0. Further, addition of P_{30} with N_{60}, instead of improving the situation lowered the population visibly as it will be evident from T_6 (7.57%) receiving $N_{60}P_{30}K_0$. Full dose of N.P.K. ($N_{90}P_{45}K_{90}$ applied in T_3) supported a low collembolan population

(12.12 %) than T_1 receiving one-third dose of N.P.K. The cumulative yield of fibre during the period under investigation was almost uniform in the plots receiving $N_{60}P_{30}K_{60}$ (T_2, T_4, T_8). It is of interest to note that T_9 though received identical dose of fertilizer (*i.e.*, N_{60} P_{30} K_{60}), its yield was lowest with the resulting lowest population of Collembola presumably due to its regular chemical weeding during the cultivation of all the three crops.

An analysis of data obtained for eight months during paddy cultivation shows that highest population build up of Collembola was associated with T_8 (22.09 %) followed by T_3 (19.33 %), T_9 (16.57 %), T_4 (13.25 %), T_7 (12.70 %), T_1 (8.28 %) and T_6 (7.37 %). The highest population of Collembola in T_8 receiving $N_{120}P_{60}K_{60}$ as T_4, might be due to the application of F.Y.M. regularly during jute cultivation. Yield of paddy also in this treatment is higher being 4493 kg/ha than its counter part, *i.e.*, T_4 (4393 kg/ha). Highest yield was, however, associated with T_3 receiving $N_{180}P_{90}K_{90}$ with corresponding collembolan population of 19.33 % vs. 4550 kg/ha. From the above, it may be inferred that while the higher dose ($N_{180}P_{90}K_{90}$) helps to boost the crop yield by 57 kg/ha more than the application of $N_{120}P_{60}K_{60}$ as applied in T_8 (with F.Y.M. during jute cultivation), there is reduction in the population slightly, *i.e.*, by 2.76 %. It remains to be seen that if the application of higher dose of fertilizer equivalent to T_3 during paddy cultivation can boost the yield of crop in T_8 without reduction in the population of Collembola or conversely, if application of F.Y.M. in T_3 can improve the population. In general, it is to be noted that application of N.P.K. (particularly N) encourages the development of population of Collembola. In T_9, where chemical weeding is practiced, collembolan population though is effected but not so much as compared to that of other type of cultivation probably due to the fact that high degree of moisture during paddy cultivation dilutes the effect of chemical weedicides. Mean yield of paddy, however, in this plot was lowest in comparison to other plots not undergoing chemical weeding.

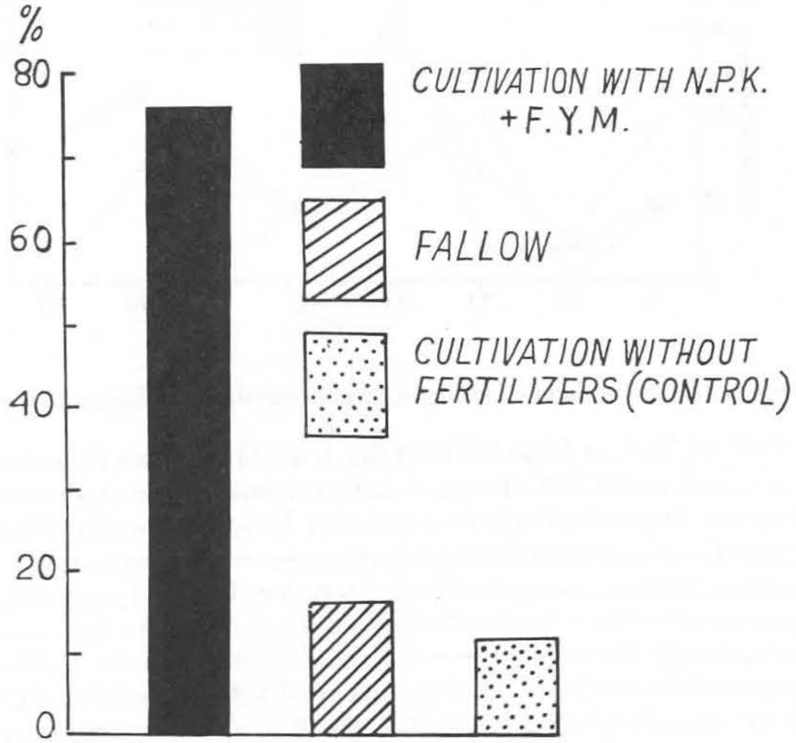

Figure 2 Effect of fertilizers on collembolan population.

An overall analysis of the effect of fertilizers (N.P.K. + F.Y.M.) on total collembolan population is given in Fig. 2. It is evident that while cultivation with the application of fertilizers helps to boost the collembolan population, cultivation without fertilizers depresses it.

Conclusions

Organic and inorganic fertilizers affect the numbers of Collembola favourably, former exerting direct influence by providing as food and the latter indirectly through their effect on the growth of plants and microorganisms (EDWARDS & LOFTY, 1969). Present investigations reveal that rotation of crops with the application of fertilizers increase the population of those species which are able to tolerate the rigors of cultivations. It is further observed that effects of various doses of N.P.K. during jute, paddy and wheat cultivations are reflected in their population dynamics. Long term use of the chemical weedicides, as used in the present experiment in T_9 have a significant effect in reducing the population of Collembola as well as crop yield. During paddy cultivation, effects of chemical weedicides, however, are less pronounced presumably due to the high degree of moisture and intermittent rains which dilute their effect. Contrary to chemical weeding, hand weeding favours better development of the euedaphic species. Further, certain degree of species specificity is observed in relation to three types of crops, dealt with in this investigation.

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